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PROVISIONAL SPECIFICATION.

"Improvements in Bi-focal Lenses and their Manufacture, and in Apparatus to be employed in the said Manufacture".

We, MALCOLM BENTZON, of 188, Strand, in the County of London, carrying on business as an Engineer, under the style of Malcolm Bentzon & Co., and ALFRED HENRY EMERSON Junior, of 26 Eyre Street Hill, Clerkenwell in the County of London, Manufacturing Optician, do hereby declare the nature of this invention to be as follows:—

Our invention relates to solid bi-focal lenses, more especially intended for spectacles and eyeglasses, that is, lenses made from one piece of glass, pebble, or the like, with two foci, and our said invention consists in improvements in the lenses themselves and in their manufacture, and in apparatus to be used in such manufacture. The solid bi-focal lenses, of the kind known as "solid down-curve bi-focals", hitherto produced, or proposed, have a ridge between the two foci which ridge has a bad appearance and prevents the lenses from being cleaned with the same ease as ordinary lenses, but hitherto no practical means have, so far as we are aware, been devised to successfully produce two different foci optically correct on one piece of glass, or the like, without a ridge, and it is the object of one part of our invention to provide practical means for the production of such lenses, whereby we obtain optically correct solid down-curve bi-focal lenses wherein the curvatures of the two foci of the lens join each other exactly on the same plane, so that the dividing line is practically invisible, and so that there is no obstruction to the sight and no disfigurement to the wearer, and so also that the lens can be cleaned as easily as an ordinary lens.

The lens may be made of any known, or suitable, kind of glass, pebble, or the like, capable of being used for the purpose, but we will refer to it as glass.

Hitherto it has been the general practice to rough grind and smooth grind lenses for spectacles and eyeglasses by hand, the polishing only being effected by machinery, but, by the means according to our invention, we are able to perform all three operations by machinery and to operate upon the two curvatures of one lens, or of two, or more, lenses, simultaneously.

The apparatus which we have devised for this purpose consists of a framework supporting bearings in which is mounted a lower spindle carrying a disc, or lens holder. Perpendicular to the face of the lens holder are upper spindles, supported in bearings in carriers, preferably each consisting of an arm hinged, or pivotted, at one end to a moveable block adjusted by a screw, or lever, and at the other end moveable in a radial, vertical, and horizontal, direction, so that the tool carried by each spindle can be set exactly above the glass, or glasses, to be operated upon. The said upper spindles each carries at the end nearest the lens holder a detachable hollow and spherical grinding, or polishing, tool attached in such a manner that it will automatically take up and keep its proper position upon the surface of the glass being operated upon, the connection of the spindle with the tool being effected by a universal joint pre-

ferably consisting of a ball on the end of the spindle engaging in a corresponding recess in the upper part of the tool, and a tongue engaging with a slot for conveying motion to the tool. The said upper spindles and the lower spindle are fitted with driving gear preferably consisting of pulleys driven by bands and the relative speeds of the several spindles can be regulated by variable speed cones, friction clutches putting in different speed gear, or other suitable contrivances.

The glass, or glasses, having been fixed in position upon the lens holder, the speed gear regulated, the rough grinding tools put in place and adjusted, and the motive power applied, the two curvatures are ground simultaneously, the tool nearest the centre preferably rotating in the reverse direction to that in which the lens holder rotates, whilst the other tool rotates in the same direction as the lens holder or in the opposite direction, as required, or the lens holder may be stationary and the tools only rotated. When the desired curvatures have been approximately given to the glass, or glasses, smooth grinding tools are substituted for the rough grinding tools and, when the required curvatures have been obtained, polishing tools covered with felt, or other polishing media, are substituted for the smooth grinding tools, the three operations of rough grinding, smooth grinding, and polishing, being performed in a similar manner.

The amount of curvature obtained in grinding lenses has hitherto been dependent on the curvature of the grinding tools which have been much larger than the glasses operated upon, but the tools which we employ are less than half the size of the said glasses so that we are practically independent of the curvature of the tools which, being hollow, and having a thin grinding edge, and operating as aforesaid in the positions hereinafter explained, wear away and adapt themselves to the constantly changing curvatures of the glass. The amount of curvature desired is obtained by varying the surface velocity at which the grinding, or cutting, material is moved in contact with the surface of the glass, as well as by varying the time of grinding and the number of tools used. The periphery of each grinding tool coincides with the part of the glass, or glasses, where the one curvature ends and the other begins, one of the said grinding tools being between the said part and the centre of the lens holder whilst the other tool, or tools, is, or are, between the said part and the periphery of the said lens holder. The production of a bi-focal lens without a ridge depends, in addition to the operation of the tools hereinbefore described, upon the relative time of grinding each portion of the lens, any ridge occurring through an error of calculation may easily be got rid of by further grinding only that portion which is too high.

The said solid bi-focal lenses can be made from convex, or concave, spectacle lenses, or glasses, of any form, or from flat glass discs. To ensure both portions of the lens being correctly centered, we slightly vary the diameter of the dividing line between the two foci, that is to say, the higher the power of the glass and the difference between the two foci, the larger the aforesaid diameter must be. The diameter required for any given combination of lenses may be worked out by the known formula.

When solid bi-focal lenses are made from flat glass, after the two curvatures have been ground on the one surface, the glass is cut into two, or more, parts, each part containing two curvatures. The other surface may then be ground in the ordinary, or any suitable, way.

The apparatus may be operated by manual, or other, power and each one may be worked separately, or several may be worked in sets of any required number, and each spindle may be provided with suitable gear to connect and disconnect the motive power therefrom as desired.

Our invention further relates to solid bi-focal lenses having a well defined dividing line, or ridge, between the two foci. In such lenses a correct optical centering, which is of the utmost importance, has not been obtained by any of the means

of production hitherto introduced in which the centering varies according to the curvatures of the lenses and the relative sizes of the two portions, and, as far as we are aware, no provision has been made for producing the optical centre, at will, in any desired position, and this is an important drawback and has prevented a bi-focal lens from being properly made out of one piece of glass.

According to this part of our invention, we obtain any desired position of the optical centre of a lens by the means hereinafter described. We provide a block made from metal, or other suitable material, and preferably of a size suitable for supporting holders for two lenses, and we shape the face of the block, from the centre towards either end, so as to form an angle at the mid line according to the curvature of the lens, or lenses, to be operated upon, the curvatures to be ground thereon, and the position of the optical centre desired. By calculations well understood by manufacturing opticians the correct angles for lenses of all curvatures can be easily ascertained.

The said angle block is provided with a hole on each angled face and in each hole a lens holder is fixed, the position of the said holes depending upon the degree of angle used and being easily found by calculation. Before the lenses are placed on the lens holders, a portion of each lens is cut off to a straight edge to permit of the two lenses being placed under one grinding tool.

Although we have mentioned two faces for the said angleblock, it may also be made with three, or more, faces, having equal angles, each face being provided with a hole for a lens holder, the lenses, in this case, being shaped in such a way as to bring together the parts of the lenses to be operated upon by the tool.

The said angleblock is held by a chuck, or other device, in a lathe, or the like, and the glasses are cemented to the lens holders and the tool rotated against the lens, or the lens rotated against the tool; the reading portion of the lens is then ground away until the correct curvature has been arrived at, when it will be found that the optical centre is invariably in the predetermined position.

Instead of making the angleblock with flat faces, we may make it with curved faces, in which case the under sides of the lens holders are cut away to suit the curvatures of the block and the calculations will be made for tangents to the curved surface. The machine and tools hereinbefore described may be used to make lenses on this plan one of the tool arms only being used.

In solid bi-focal lenses, having a well defined and bright dividing line, or ridge, between the two portions, the said ridge forms a third reflecting surface, which is very irritating and injurious to the eye of the wearer, and, the edge of the ridge being sharp, renders the lens very liable to be damaged on coming into contact with a hard surface. These defects it is a further object of my invention to overcome, and this we effect by obscuring, or "greying", the said ridge, so that it does not constitute a reflecting surface, and by chamfering the sharp edge of the ridge, so that the lens will not be liable to be injured on coming into contact with a hard surface.

Dated this 29th day of December, 1904.

JOHNSONS & WILLCOX,
47, Lincolns Inn Fields, London, W.C.
Agents.

COMPLETE SPECIFICATION.

"Improvements in Bi-focal Lenses and their Manufacture, and in Apparatus to be employed in the said Manufacture".

We, MALCOLM BENTZON, of 188, Strand, in the County of London, carrying on business as an Engineer under the style of Malcolm Bentzon & Co.; and

Improvements in Bi-focal Lenses and their Manufacture, &c.

ALFRED HENRY EMERSON Junior, of 26, Eyre Street Hill, Clerkenwell, in the County of London, Optician, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to solid bi-focal lenses, more especially intended for spectacles and eyeglasses, that is, lenses made from one piece of glass, pebble, or the like, with two foci, and the said invention consists in improvements in the lenses themselves and in their manufacture, and in apparatus to be used in such manufacture. The terms we use in this specification are the optical terms customarily used by opticians in connection with spectacles and eyeglasses. Bi-focal lenses, of the kind known as "solid down-curve bi-focals", (as shewn for instance in face view and section in Figure 1 of the accompanying drawings), hitherto produced, have a ridge between the two foci, but hitherto no practical means have, so far as we are aware, been devised to successfully produce out of one piece of glass a lens with two different foci without a ridge, and yet optically correct, that is to say, a lens in which the optical centres of the two foci can be at any required distance from each other, or from the geometrical centres, and the spherical curves yet be true and the surfaces be free from ring and tool marks. By ridge we mean a difference in level at the place where the curvatures of the two foci meet, as shewn at 22 in the section of Figure 1, and it is the object of one part of this invention to provide practical means for the production of such lenses wherein the curvatures of the two foci of the lens join each other exactly on the same plane, so that the dividing line is practically invisible, and so that there is no obstruction to the sight.

By the means hereinafter described lenses may be made from any suitable form, and kind, of glass, pebble, or the like, capable of being used for the purpose, but we will refer to it as glass.

The apparatus provided in accordance with this invention, for this purpose, consists of a framework supporting bearings in which is mounted a lower spindle carrying a disc, or lens holder; and, capable of being arranged perpendicularly, or at other angle, to the face of the lens holder is an upper spindle, or are upper spindles, supported in bearings in a carrier, or carriers. The two curvatures may be formed at one operation, or the glass operated on may already be of one of the bi-focal curvatures and a machine with a single upper spindle and tool be used to make the other bi-focal curvature, and as, in making such two curvatures simultaneously, two single tool machines can be used, instead of using a single machine with two, or more, tool-carrying spindles, it will also be understood from the description of a single tool machine how either two of these, or a machine with two, or more, tool-carrying spindles on one framework, can be used, so that, if desired, the two curvatures of one lens, or of two, or more, lenses, can be ground, or operated upon, simultaneously.

Figure 3 is a sectional side elevation of a machine provided with means according to this invention. The framework 1 carries vertically adjustable and fixable bearings 2 in which rotates the spindle 3 carrying the lens-holder arrangement. The upper spindle 4 is supported in bearings in a carrier head 5 on an arm 6, which may carry a weight, 6* or weights, by altering which the pressure on the work can be regulated. The said arm 6 is hinged, or pivoted, at one end to a lever 7 carrying a moveable block 7* adjusted by a screw 8 supported by a spring 23, so that its other end, with the carrier head 5, is moveable in any required direction, and the tool 9, carried by the spindle 4, can be set in the required position above the glass, or glasses, 10, to be operated upon. 8* is a support for the arm 6 when turned back. The said tool 9 is attached to the spindle in such a manner that, whilst it can be readily attached and detached, it will automatically take up and keep its proper position upon the glass being operated upon. This connection of the spindle 4 with the tool 9 is shown as being effected by a joint consisting of a ball 11 on the end of the spindle 4 engaging in a corresponding recess in the axial line of the tool, and a tongue 12 engaging with slots respectively in the

collar 13 on the spindle 4 and in the upper part of the tool 9 for conveying motion to the said tool, which is set between the centre of the lens and its periphery. The said upper spindle 4 and the lower spindle 3 are fitted with driving gear, which may consist of pulleys driven by bands, or other devices, whereby the ratio of their speeds can be regulated through the intervention for example of variable speed cones, or friction clutches, putting in different speed gear, or other suitable contrivance. The glass, or glasses, having been fixed in position on the lens-holder 17, and these fitted to the hereinafter described angle blocks 16 and secured to the chuck 3* of the machine, and the speed gear regulated, and the rough grinding tools having been put in place and adjusted, and the motive power applied, the curvature is ground, or if two machines, or two, or more, tools carried by two, or more, arms on one framework be used, two curvatures are ground simultaneously, for example as illustrated in Figure 4, where two separate machines, such as are shewn in Figure 3, are presumed to be used. The tools may rotate in the reverse direction to or in the same direction as, that in which the lens-holder rotates, or the lens-holder may be stationary and the tools only rotate, in which latter case the tool is, or tools are, rotating on the spindle, or spindles, and travelling at the same time round the surface of the lens, as shewn in plan in Figure 5. When the desired curvatures have been given, or approximately given, to the glass, or glasses, a smooth grinding tool, or smooth grinding tools, is, or are, substituted for the rough grinding tool, or tools, the smooth grinding tools being preferably of a softer metal (say brass) than the rough grinding tools, which may be for example of steel. When the required curvatures and smooth surfaces have been obtained, polishing tools, covered with felt, (as shewn in Figure 11), or other polishing material, are substituted for the smooth grinding tools and a polishing medium is substituted for a grinding medium, and thus the three operations of rough grinding, smooth grinding, and polishing, can be performed in a similar manner.

The amount of curvature produced in grinding lenses has hitherto been dependent on the form of the grinding tools which generally are larger than the lenses operated upon, and are solid and have a continuous curved operating surface corresponding to the curve to be produced, that is to say, a concave tool of say a radius of four inches will produce a convex curvature of an equal radius and the tools being rotated on a fixed axis, will grind the lenses quicker at one place than at another; it is therefore the custom to give various eccentric motions to the tool, or the lenses, with the object of grinding equally all parts of the surface of the lenses.

The tools are, according to this invention, such that we are entirely independent of the continuous curve of the grinding tool, or tools, and for this purpose we make the tools hollow, that is to say, they are hollowed out by perforation, or by indentations, or recesses, in such a way that, when the tool, or tools, and the lens-holders are rotated, as hereinafter described, the whole of the surface of the lens is equally operated upon and a true spherical surface obtained, the tool having a larger grinding surface in such parts as have a tendency to grind away quicker than they have in the other parts. The tools are rotated in the position described and gradually wear away and adapt themselves to the constantly changing curvatures of the glass. The amount of curvature depends upon the relative surface velocity of the tools and the lenses carried by the holders and the direction in which they are rotated, any alteration in the ratio and the direction, resulting in an alteration in the degree of curvatures of the lens. For instance; to increase the curve of a convex surface, or to decrease the curve of a concave surface, the bottom spindle should rotate quickly, whilst the tool should rotate slowly, and preferably in the opposite direction. In this way a greater amount of friction is produced at the edge than at the centre. To decrease the curve of a convex surface, or to increase the curve of a concave surface, the contrary is done. It will soon

be found by experience what relative speeds of the tools and the lenses shall be employed when the exact curvature has been arrived at, so that the process of smooth grinding may be continued without altering the curvature.

It will thus be seen that by the use of the hollow tools described and by varying the speed and direction of rotation of the tools and the lens-holders, we are entirely independent of any continuous curve on the tools. Any ridge occurring through the distance portion being ground away more than the reading portion, or *vice versa*, may be rectified by further grinding only that portion which is too high.

In forming two curvatures simultaneously, the periphery of each tool coincides with a part of the glass, or glasses, where the one curvature ends and the other begins, as clearly seen by the dotted lines at 9 in Figure 4, one of the said tools being between the said part and the centre of the lens-holder, whilst the other tool is between the said part and the periphery of the said lens-holder.

To insure both portions of the lens being correctly centred, the radius of the dividing line between the curvatures of the two foci is slightly varied, that is to say, the higher the power of the glass, and the difference in distance between the two centres, the larger the aforesaid radius must be. The radius required for any given combination of lenses can be worked out by the rules known to opticians.

Figure 6 shews a flat glass disc on the lens holder after the formation of the two curvatures.

Figure 7 shews, in plan, two lenses with curvatures ground upon them; the said lenses are cut to a flat edge, as shewn at 24, so that they may come close together; 25* are "fish-tail" pieces to fill up the gaps and to form a continuous circle of glass.

In some cases it will be advisable, before rough grinding, to use an ordinary solid tool rigidly connected to a vertically disposed upper spindle to remove the projecting surface at the meeting central line due to the tilt of the glasses.

Figure 8 shews a side sectional elevation of an arrangement of machine suitable for grinding two curvatures simultaneously, instead of using two single machines, or a double-armed machine, for the purpose.

The inner tool is carried on a spindle 25 mounted in bearings in a bracket 26 on a sleeve 27, the spindle being driven by the pinions 28, 29, the latter on the shaft 30 driven by a band passing round the pulley 31. The sleeve 27 is provided with a driving pulley 32. The outer tool is carried by the spindle 33 carried in a bearing 34 secured to an arm 35 removeably fixed to the sleeve 36 carried in the head 5 of the machine and provided with driving pulleys 37, and a sleeve 38 provided with a pulley 39 carries a pinion 40 engaging with a pinion 41 on the spindle 33. Thus each tool has variable rotary motion and motion of revolution given to it. The arm 35 carrying the bearing 34 for the outer tool can be replaced by longer, or shorter, arms in accordance with the size of glass to be operated on and of the reading portion required.

Only one tool is shewn for operating upon the outer surface, but two, or more, tools may be used, the inner surfaces being preferably operated upon by one tool only, the plan Figure 5 shewing a lens-holder with several outer tools acting simultaneously and one inner tool. Figures 9 and 10 shew, in vertical section and plan of underside, the lower part of a hollow tool, in which the hollow is shaped as shewn instead of being simply annular. The acting surface can be either curved, or flat.

Figure 11 shews, in vertical section, and Figure 12 in plan of top side, another form of hollow tool, Figure 11 shewing its attachment to the ball on the end of the spindle. The mid line of the acting surface of the periphery of the tool is preferably coincident with the geometrical centre of the surface, or surfaces, being operated upon, as seen for example in Figure 3. The spring 14 is fixed in the interior of the tool in such a way that the ball 11 on the spindle 4

can be slipped past the said spring to attach, or remove, the tool 9 whilst the spring normally keeps the tool on the spindle. The tool shewn is a polishing tool as it has polishing material 15 on its acting edge. Instead of attaching the tools to the spindles, as described, they may be attached in other convenient way, for example by a squared opening in the interior of the tool to receive a square part on the end of the spindle, as indicated at 42 in Figure 8.

The annular tool shewn in Figures 11 and 12 is most suitable for polishing, but is suitable also for either rough, or smooth, grinding. The tool shewn in Figures 9 and 10 is more suitable for rough, or smooth, grinding than for polishing.

The polishing felt, or equivalent material, should be made sufficiently hard in order to obtain perfectly polished spherical surfaces on the lenses. For this purpose the felt, or the like, can be boiled in pitch. Rouge, or any ordinary, or suitable, polishing medium can be used for polishing.

When solid bi-focal lenses are made from flat glass, after the two curvatures have been ground on the one surface, as in Figures 6 and 8, the glass is cut into two, or more, parts, each part containing two curvatures, either each the same in dimensions, or one larger than the other, and it will be evident that the glass may be cut so that the whole, or any desired part, of the inner curvature may be included in one portion. The opposite surface may then be ground and polished in the ordinary, or any suitable, way.

The apparatus may be operated by manual, or other, power, and each machine may be worked separately, or several machines may be worked in sets of any required number, and each spindle may be provided with suitable gear to connect and disconnect the motive power therefrom as desired.

It will be seen that the arrangement shewn in Figure 3 is operating to form the bi-focal curvatures of a lens of the kind shewn in Figure 1 and that, by the arrangement shewn in Figures 4, 5 and 8, the bi-focal curvatures of a lens can be formed of the character shewn in Figure 2.

In solid bi-focal lenses having a well defined dividing line, or ridge, between the two foci, (as in Figure 1), correct optical centering, which is of the utmost importance, has not been satisfactorily obtained by any of the means of production hitherto introduced in which the centering varies according to the curvatures of the lenses and, as far as we are aware, no provision has, previous to this invention, been made for producing the optical centre, at will, in any desired position.

According to this invention, any desired position of the optical centres of a lens is obtained by the means hereinafter described. A block 16 is provided, it being made from metal, or other suitable material, and being preferably of a size suitable for supporting holders 17 for two lenses, and the face of the said block 16 is shaped from the centre towards either end, so as to form an angle at the mid line 18, according to the curvature of the lens, or lenses, to be operated upon, the curvatures to be ground thereon, and the position of the optical centre desired. By calculations, well understood by manufacturing opticians, the correct angles for lenses of all curvatures can be easily ascertained.

In Figure 3, shewing two convex lenses being ground, the angles are downward and outward, whilst in Figures 13 and 14 they are downward and inward for grinding concave lenses.

Figure 13 is a vertical longitudinal section and Figure 14 is a plan of the underside.

The said angle block 16 is provided with a hole in each angled face and in each hole the stem of a lens holder 17 is received and fixed, which can be done by means of screws 19, the position of the said holes depending upon the degree of angle used and being easily found by calculation. The block 16 can conveniently be secured to the chuck 3* at the top of the spindle 3 by screw-bolts screwed down by nuts 20 so that the heads of the bolts bear

on undercut parts of the slots 21 which, when the nuts 20 are slackened, allow of the block 16 being removed by a twisting movement. Before the lenses, (after being cemented on the lens-holders), are fixed in the angle block, they are correctly centred on the lens-holders, a portion of each lens being cut off to a straight edge to permit of the two lenses being placed under and operated upon by one grinding, or polishing, tool, as shewn in Figure 3.

Although we have mentioned two faces for the said angle block 16, it may also be made with three, or more, faces, having equal angles, each face being provided with a hole for a lens-holder, the lenses, in this case, being shaped in such a way as to bring together the parts of the lenses to be operated upon by the tool.

Where the block 16 is to be employed for operating upon glass in which the reading portion of the lens is to exceed a semi-diameter and the glass has therefore to project beyond the lens-holder, only one such holder 17 will be secured on the block 16, where another would interfere with the placement of the glass.

The said angle block 16 is carried by a spindle, such as 3, or its equivalent, and the glasses are cemented to the lens-holders 17 and the tool 9 rotated against the lenses, or the lenses rotated against the tool, the reading portion of the lenses being then ground away until the correct curvature has been arrived at in the manner already described, when it will be found that the optical centre is invariably in the predetermined position.

Instead of making the angle block 16 with flat faces, it may be constituted by a curved head, as shewn in vertical section and plan respectively in Figures 15 and 16, the undersides of the lens-holders 17 being cut away to suit the curvatures of the head 16 and the calculations may be made for tangents to the curved surface at the centre of the lens-holder. In solid bi-focal lenses, having a well defined and bright dividing line, or ridge, between the two portions as in Figure 1, the said ridge forms a third reflecting surface, which is very irritating and injurious to the eye of the wearer, and, the edge of the ridge being sharp, renders the lens very liable to be damaged on coming into contact with a hard surface. These defects can be overcome by obscuring, or "greying", or leaving unpolished, the said ridge, so that it does not constitute a reflecting surface, and by chamfering the sharp edge of the ridge, so that the lens will not be liable to be injured on coming into contact with a hard surface. This can be done in any suitable way, for example by a strip of copper, or other suitable material, held against the said ridge whilst the angle block carrying the lens-holder rotates.

In cases where the lenses are required to be decentered, the lens-holder can be tilted to the required degree and wedges, washers, or the like, placed beneath.

Although, as before stated, the means described can be used for making lenses from any suitable form of glass, bi-focal lenses having double convex surfaces, or periscopic surfaces, and with the curvatures of the foci joining each other exactly on the same plane, which lenses are optically correct, constitute new articles of manufacture.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for use in the manufacture of bi-focal lenses, the said apparatus consisting of the arrangement and combination of parts, substantially as hereinbefore described and illustrated in either Figure 3, or in Figure 8, of the accompanying drawings.

2. In a machine for making bi-focal lenses, the combination of a tool, or tools, adapted to act to form a spherical surface, or spherical surfaces, which tool, or tools, is, or are, hollow (in the sense aforesaid) and of a diameter relatively to the surface to be acted upon and with the axis on which the

tool rotates and the axis of the lens-holder at an angle to each other, all as hereinbefore described and shewn, and means whereby the ratio of speed between the tool, or tools, and the glass can be varied to vary the spherical curvature of the lenses; substantially as hereinbefore described.

3. In an arrangement according to Claim 2, mounting the tool, or tools, so that it, or they, is, or are, capable of oscillatory motion on the driving spindle, or spindles.

4. The manufacture of bi-focal lenses by rough grinding, smooth grinding, and polishing, glass, or the like, by means substantially as hereinbefore described.

5. In, or for, apparatus for use in the manufacture of bi-focal lenses, a tool adapted to grind, or polish, spherical surfaces and made hollow as herein-before defined.

6. In, or for, apparatus for use in the manufacture of bi-focal lenses, an angled, or curved, block, or support, provided with a lens-holder, or lens-holders, adapted thereto; substantially as, and for the purpose, hereinbefore described.

7. As a new article of manufacture, a bi-focal lens manufactured by means as hereinbefore described and having double convex surfaces as shewn in Figure 2 (or periscopic surfaces) and with the curvatures joining each other exactly on the same plane, which lenses are also optically correct, as herein-before defined.

Dated this 30th day of October, 1905.

JOHNSONS & WILLCOX,
47, Lincolns Inn Fields, London, W.C.
Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1906.

[This Drawing is a full-size reproduction of the Original.]

Fig. 1.

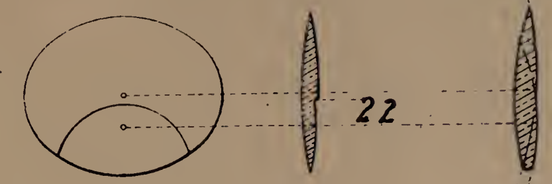


Fig. 2.

Fig. 3.

Malby&Sons, Photo-Litho.

Fig. 13.

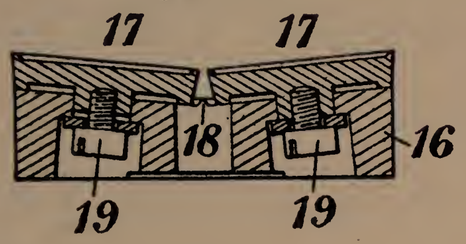


Fig. 14.

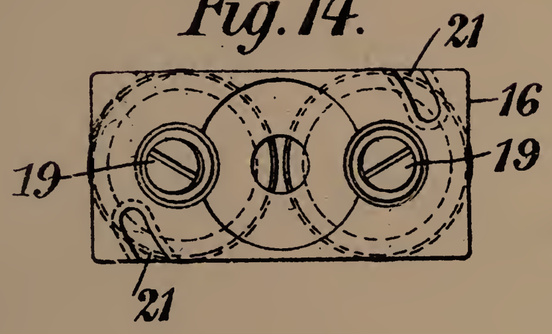


Fig. 15.

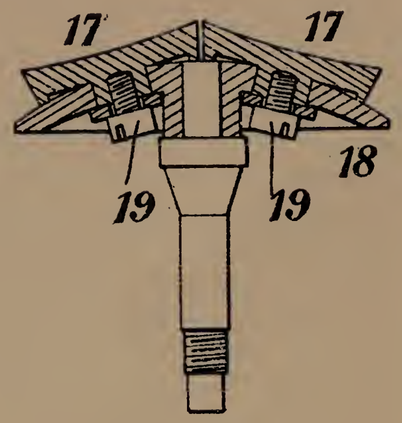


Fig. 6.

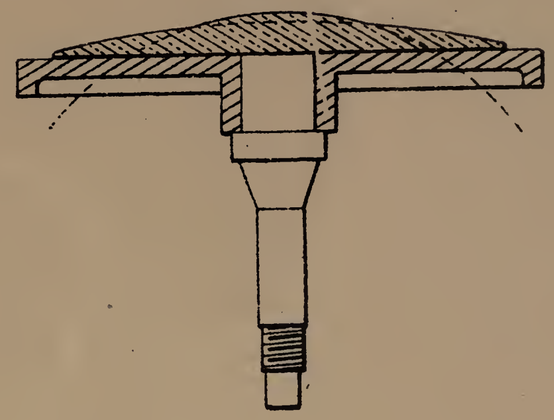


Fig. 16.

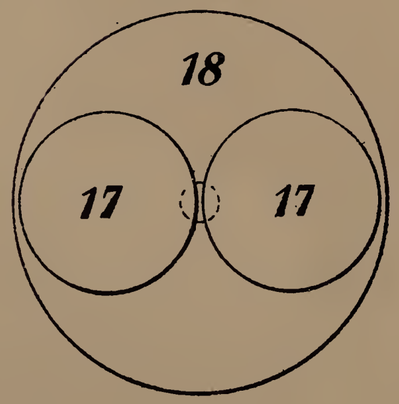


Fig. 4.

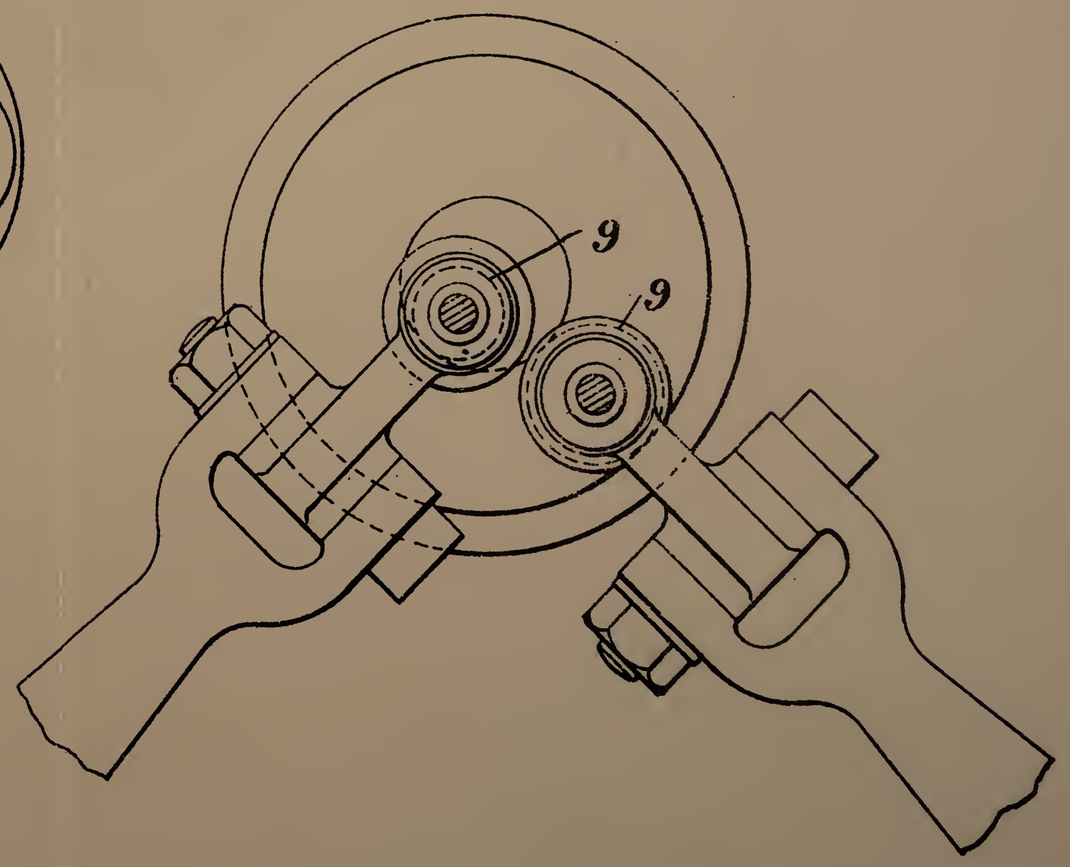


Fig. 11.

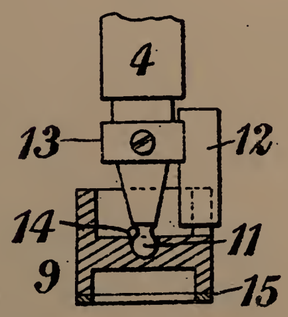


Fig. 9.

Fig. 12.

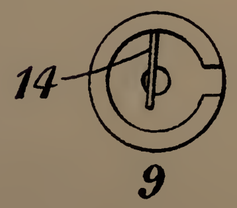


Fig. 10.

Fig. 8.

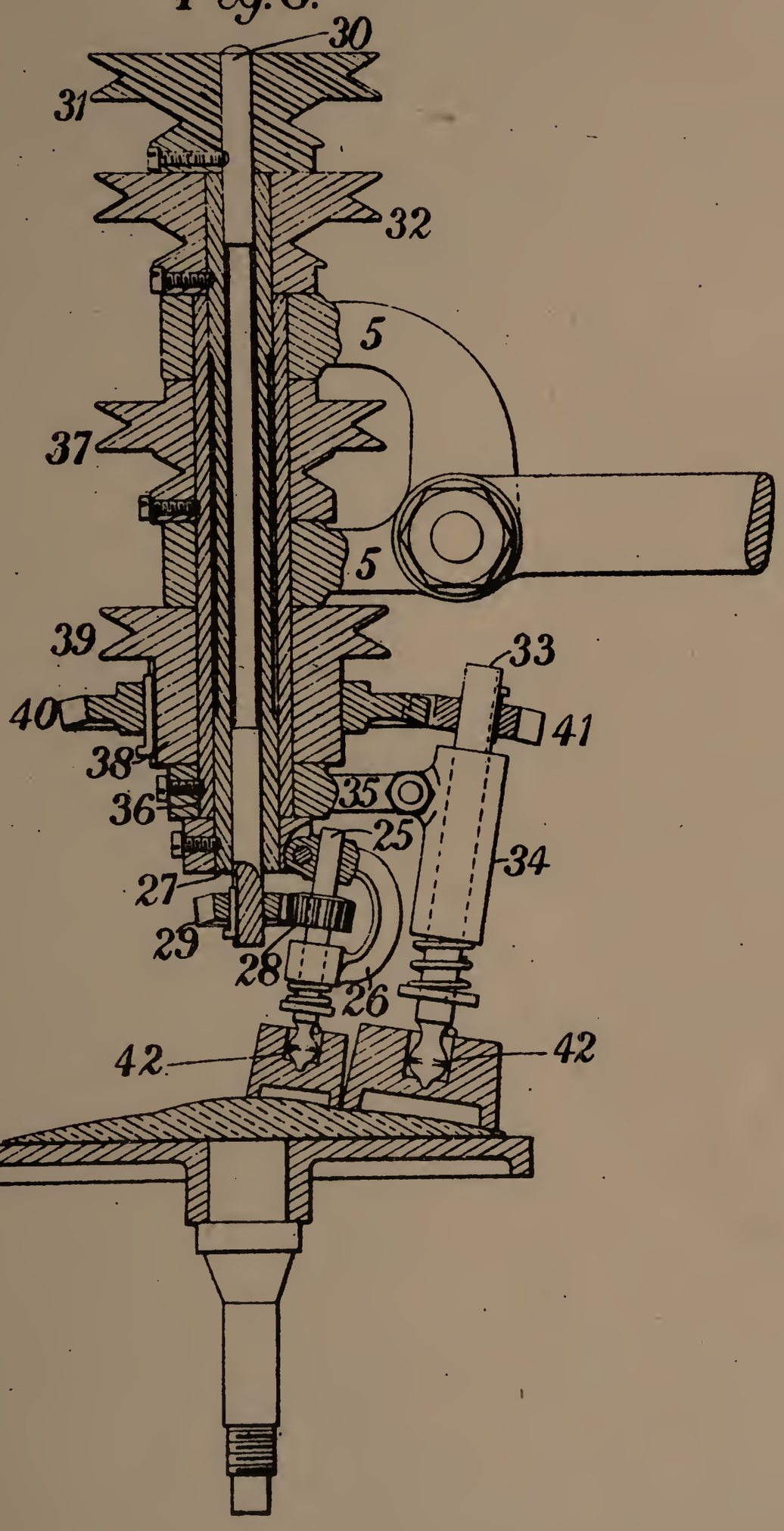


Fig. 5.

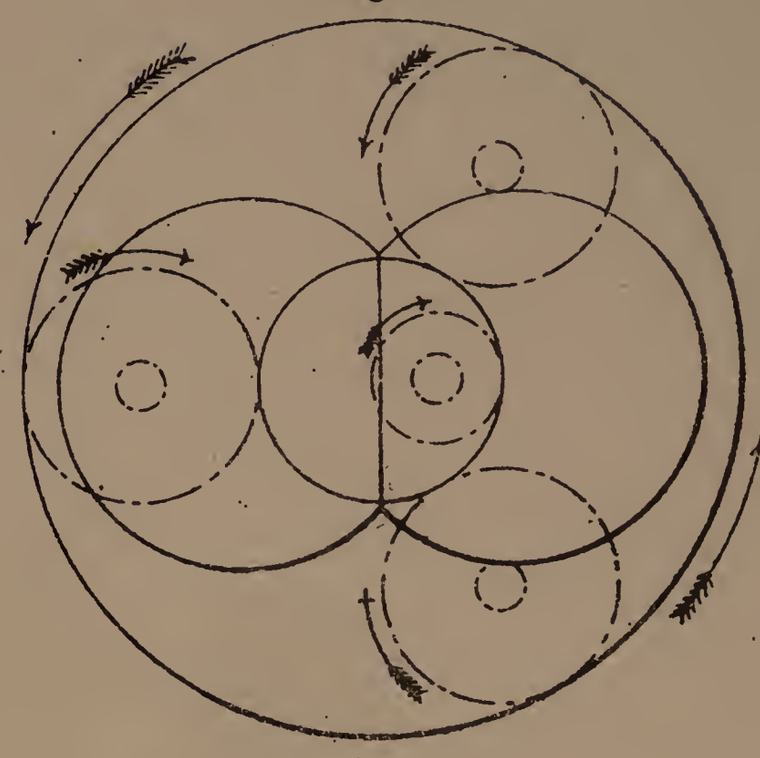
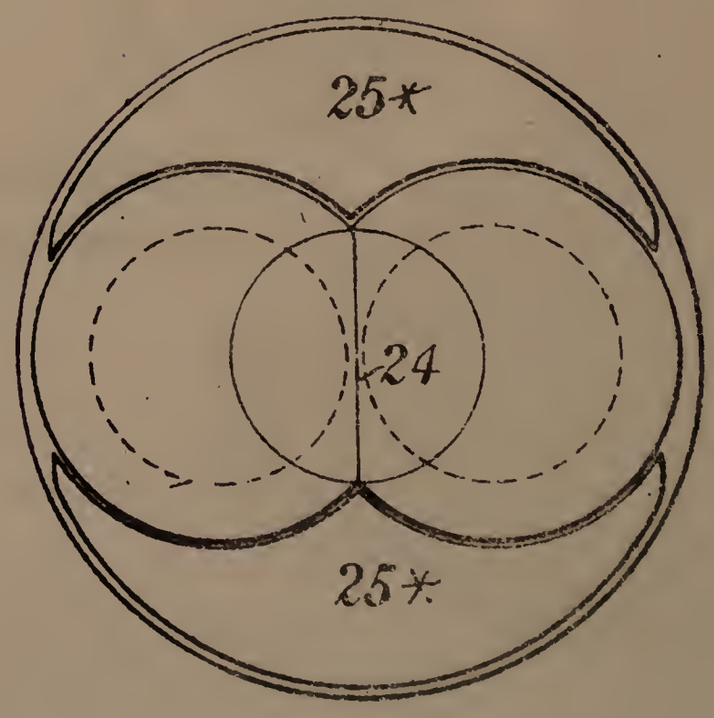


Fig. 7.



[This Drawing is a reproduction of the Original on a reduced scale.]

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